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FLAME TESTS FOR FLEXIBLE VENTILATION MATERIALS AND MINE BRATTICE CLOTH OPERATING PROCEDURES

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ABSTRACT

Flammability tests are carried out on a variety of flexible materials and brattice cloth employed for the construction of mine ventilation ducts and other applications, in order to determine their fire-resistance. The aim is to reduce possible threats to safety of mine workers, caused by the use of such products. Standard tests are used for product evaluation purposes, including National Coal Board (NCB)specification 245/1961, and an interim large scale gallery test recently introduced at CEAL, based on a similar practice at Mine Safety and Health Administration (MSHA)in the U.S.

This document serves as a guide for the operations to follow proper test procedures. Special attention has been given to the sequence of operations and safety precautions necessary while conducting the required tests at Canadian Explosive Atmospheres Laboratory (CEAL). Several test layout diagrams and some test recording sheets are also included to facilitate testing in a systematic and an organized manner.

KEYWORDS: Ventilation, flames, fire-resistance, materials, testing, procedures, standards, evaluation, certification, mines, safety.

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ESSAI À LA FLAMME SUR DES MATÉRIAUX FLEXIBLES ET DU TISSU SERVANT À LA CONSTRUCTION DE CLOISONS D'AÉRAGE DANS LES INSTALLATIONS MINIÈRES

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RÉSUMÉ

Un assortiment de matériaux souples et de tissus utilisés pour la construction des cloisons d'aérage dans les mines, ainsi qu'à d'autres fins, ont été soumis à des essais à la flamme en vue de déterminer leurs qualités réfractaires. Par ces essais, on cherche à réduire les risques éventuels pour la sécurité des travailleurs de la mine que comporte l'utilisation de ces produits. Des essais normalisés sont menés afin d'évaluer les produits qui doivent être conformes à la spécification 245/1961 du National Coal Board (NCB). De plus, ils sont soumis à un essai provisoire, sur grande échelle, dans une galerie. Cet essai qui a été élaboré récemment par le Laboratoire canadien de recherche sur les atmosphères explosives (LCRAE) est fondé sur une façon de procéder semblable observée par la Mine Safety and Health Administration (MSHA), aux États-Unis.

Le présent document est destiné à servir de guide sur la façon de procéder pendant essais. Le déroulement du mode opératoire et les mesures de sécurité qui ont été observés pendant les essais au Laboratoires canadien de recherche sur les atmosphères explosives (LCRAE) ont fait l'objet d'une attention particulière. Plusieurs schémas et quelques feuilles d'enregistrement sont également incluses afin de que les essais puissent se dérouler d'une façon systématique et ordonnée.

Mots-clé : Aérage, flammes, propriétés réfractaires, matériaux, essais, façon de procéder, normes, évaluation, homologation, mines, sécurité.

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INTRODUCTION

Ventilation ducts are generally made from plastic materials reinforced with either textile fibres or fibreglass. Due to the inherent nature of plastic materials, these tend to be flammable unless special fire-retardant chemical compounds are mixed with the total composition at the point of manufacture. Flexible plastics and other sheets have several uses in mines including ventilation ducts, air curtains and bags for packaging of explosive materials.

During the past 10 years, the Canadian Explosives Atmospheres Laboratory has tested 154 different samples of ventilation materials. Approximately 50% of these did not meet the improved safety requirements using the test procedures as outlined in this document. In addition, research and development are maintained to improve the existing test procedures and standards.

Several standard procedures are available for both rigid and flexible materials. All flexible materials are first evaluated using the NCB spec 245/1961. If the material is found to shrink away from the ignition source, thereby providing inconclusive results, it is then evaluated by using the CEAL interim large scale flame test which is similar to the MSHA practice in the U.S. This test was introduced at CEAL in July 1985. An oxygen index test is used for quality assurance purposes which determines the minimum percentage of oxygen content in the atmosphere necessary to sustain combustion of the product. Materials are also required to meet an anti-static test if the product is to be certified for gassy mines. These tests do not form part of this document and therefore they will be described in separate reports.

The purpose of this document is to direct and train new operators as well as assist the present operators in carrying out the required tests in a safe, systematic and an organized manner.

A national standard on this subject is likely to emerge from the deliberations of the CSA committee on ventilation products. This committee

is made up of representatives from the users, manufacturers, regulatory bodies, and a Canadian Standards Association (CSA) co-ordinator.

LARGE SCALE FLAME TEST (Interim)

Summary

A sample of the flexible material is cut to 1800mm wide x 1650mm long and suspended in a vertical position inside an enclosed gallery. The flame is applied through a special multiple jetburner to one of the lower edges for 25 seconds. Continuous burning time and length of flame propagation is recorded after removal of the ignition source under both flowing and still air conditions. A separate sample is used in each case. Should the material shrivel from the heat, the burner is lifted up manually to maintain flame contact with the test material.

Equipment

1. A sheet metal gallery approximately 2m square cross-section x 6m long with an exhaust scrubber system for treating toxic exhaust gases.
2. An impinged jet burner, Solar Flow type U-10, # 640 jets with a long stem and a quick disconnect nipple for gas line connection.
3. A positive ventilation flow system to give a maximum of 1.5 m/sec air velocity in the longitudinal direction.
4. A methane cylinder (commercial grade) with suitable pressure gauge rated at 0 to 20 psig.
5. A digital anemometer to measure the air flow.
6. A gas mask preferably with fresh air supply.
7. A fire-resistant tube with quick disconnects for the fuel supply.
8. An ignition lighter with a long stem (approximately 900mm).
9. A digital stop watch accurate to 0.1 seconds.
10. A micrometer to measure the thickness of the sheets.
11. A thermometer.
12. Fire-resistant gloves.

13. A 15 pound fire-extinguisher.
14. A stainless steel rod 95mm diameter x 2200mm long for suspending the test samples.
15. A 200mm steel ruler.
16. A 5m tape measure.
17. A pair of scissors.
18. An ordinary paper stapler.

Test Conditions

1. Averaged ventilation velocity: 0 or 1.5 m/sec.
2. Ambient temperature: 20 $\pm$ 5°C
3. Flame length: 30.5 cm (12 inches)
4. Rate of gas consumption: Not Specified. #
5. Gas pressure rating: " " #

These parameters may be specified in the future to standardize the size and intensity of the ignition flame.

Operations

Following sequence of operations is recommended:

1. Measure the thickness of the fresh material and determine its weight per square meter. Record these characteristics on the test sheet.

2. Prepare two samples of flexible material cut to 1800mm X 1650mm size. Fold one edge of 1800mm side by 50mm into a loop and staple it at 100mm intervals. Make sure that the sample preparation is done on a clean surface to prevent any dust contamination.

3. Pass the steel rod (9.5mm) through the loop of the test sheet extending equally on both sides.

4. Remove all objects obstructing the inside of the gallery.

5. Suspend the sample vertically inside the gallery by passing the suspension rod ends through two hooks welded permanently to the ceiling, spaced about 2000mm apart (Ref. to Figure 1).

6. Turn on the ventilation fan and close the gallery access doors before recording the ventilation velocity at the top, middle and bottom level of the suspended sample. Ensure that the average ventilation velocity measured in the longitudinal direction does not exceed 1.5m/sec. Also ensure that the velometer is in good working order before using.

7. Take a temperature reading in the gallery and record the same.

8. Connect the burner to the methane fuel line suspended from the ceiling or the side wall.

9. Open the gallery door and light the burner with the ignition torch (having an extra long handle) while the other operator turns on the methane gas supply. Adjust the methane flow rate and the supply pressure until the flame length is 300mm (12 inches) with the burner kept away from the test sample. Measurement of the flame height should be taken at the outermost tip of the flame.

10. Shut the gallery door and let the ventilation stabilize. Then move the burner under the front lower edge of the sample. If the material shrinks or shrivels, lift up the burner manually and maintain contact with the test sheet for 25 seconds maintaining a gap of 100mm (4 inch) between the sample sheet and the burner to ensure that the length of the burn in the vertical and horizontal directions is kept approximately equal.

11. As soon as the flame is applied to the test piece, the second operator, watching from outside of the gallery, should start the stop watch and signal operator #1 when 25 seconds have elapsed. Operator #1 inside the gallery should then remove the burner from the sample.

12. Operator #1 then leaves the gallery and shuts the gallery door while operator #2 cuts off the methane supply.

13. Observe burning of the test sample from the observation window until it extinguishes itself.

14. Record the duration of continuous burning and the length of the flame propagation in the horizontal direction after the intital ignition period of 25 seconds.

15. Turn off the gallery ventilation fan after the smoke has cleared.

16. Take pictures of the burnt test sample with a polaroid camera before discarding the same.

17. Remove burnt sample and the sample rod; discard the tested sample in the garbage bin outside the building.

18. Repeat the entire procedure for a second sample in still air.

19. Clean the test chamber and all the instruments when the tests are finished; restore the instuments in their usual place in the laboratory.

20. Record any malfunctions of the equipment in the log book.

Evaluation Criteria

1. The flame propagation must not exceed 1600mm in the horizontal direction during each test.

2. The duration of continous burning shall not exceed 60 seconds in each test after removal of the ignition source.

NOTE: During the ignition period, any material that falls on the floor of the gallery and continues to burn, shall be considered when measuring the total burning time. Material is considered to have failed if any of the above conditions are not met.

Safety Precautions

1. At least two operators must be present during the entire period of testing.

2. Operators entering the test gallery should wear suitable respiratory protection during the ignition time and whenever there is a possibility of toxic gases being present in the gallery.

3. Ensure that all fuel lines are properly secured and that there is no leakage before commencing the test.

4. No part of the gas fuel lines shall be allowed to lie on the floor. These should be suspended from the ceiling of the side wall.

5. The ignition torch must have at least a 900mm (36 inch) long stem to allow the operator to stand at a safe distance for ignition of the burner.

6. Opening of the methane supply to the burner and ignition of the same should be done simultaneously to avoid accumulation of methane in the gallery before ignition. These tasks must be done by two operators.

7. If the fire gets out of control, shut off the ventilation and use a fire extinguisher or water spray from the existing waterhose to extinguish the flames.

8. It is also desirable to wear fire-resistant gloves while operating inside the test gallery.

SMALL SCALE FLAME TEST

Summary

NCB specification 245/1961 is applicable to brattice cloth and flexible ventilation material other than those which shrink from the flame in this test. A test piece of 51mm x 350mm is held vertically inside a draft-free steel cabinet with a transparent front door. A barthel burner using a mixture of 95% ethanol and 5% methanol is employed as an ignition source. The burner is held on a swivel plane inclined at 45° and the top of the burner stem is kept 51mm away from the lower edge of the test sample. A marker wire is fixed horizontally at a distance of 280mm above the bottom edge of the test sample. The flame is applied for 20 seconds and the burning times, as well as glow times, are observed after removal of the ignition source. The test becomes inconclusive if the material shows any sign of shrivelling upon application of the flame.

Apparatus

1. A draft-free test chamber of sheet steel 300mm x 350mm x 600mm high (12"x14"x24") equipped with a 150mm diameter hole on the top, transparent window in the front sliding door, a sample holding clip and a swivel inclined table for the burner. (Ref to fig: 3 & 4).
2. A barthel burner having 2mm diameter x 140mm long stem and a screw for adjusting the fuel supply. (Ref to fig: 5).
3. Fuel for the burner shall be industrial methylated spirit. It is generally prepared by mixing 5% methanol with 95% ethanol by volume.
4. A digital stop watch showirg a resolution of 0.1 seconds.
5. A portable temperature recorder with a J-type thermocouple.
6. A 460mm steel ruler.
7. A straight edge and a jackknife for cutting the samples.
8. A 6.5mm diameter steel rod for stretching and conditioning the samples.
9. Precision weigh scale.
10. A micrometer.
11. A 50ml glass beaker.

Test Conditions

1. Ambient temperature: 20 + 5°C
2. Humidity : <70% preferred
3. Flame temperature : 1175° ± 25°C on the flame tip.
4. Flame length : 175mm (7")
5. Fuel level should be 760mm above the above bottom of the burner.
6. The test chamber shall be draft free.

Operations

1. Prepare 6 pieces of 51mm x 355mm from test material and cut one piece of 216mm x 280mm for future record keeping.

2. Measure thickness of the material with a micrometer and weigh 10mmx10mm size on a precision scale. Record data on test sheet.

3. Tag one sample of 216mm x 280mm with the client's name, CEAL sample number and the test date before filing the same in the sample file.

4. Condition all 6 test pieces by first stretching them over 9.5mm diameter rod; soaking in water for three hours at room temperature and drying the same at a room temperature less than 50°C before suspending them at normal room temperature for at least 12 hours prior to the flame test. This procedure applies to the textile fibre based material only.

5. Locate the test chamber (on a portable trolley) under the designated exhaust hood test area in the main hall (Ref Fig. 7).

6. Ensure that the fuel container attached to the chamber is full with the appropriate fuel (5% methanol +95% enthanol). Add fuel if required and retain about 10cc in a beaker before replacing the fuel container in the fire-resistant cabinet.

7. Place the burner flat on its base inside the chamber; pour 5cc of fuel in the ring container around the burner for precombustion and heating of the burner stem. Cut off the main fuel supply to the burner; light the precombustion fuel.

8. When the burner stem is heated, gently open the main fuel supply and adjust the flame height by manipulating the control knob on the burner.

9. Hold a J-type thermocouple on the tip of the flame and read the temperature on portable pyrometer until it stops to climb. This temperature should read 1175° $\pm$ 25°C (not mandatory).

10. Close the fuel supply valve at the fuel reservoir and measure the time in seconds until 10ml has been consumed by the burner as seen from the glass stem along the reservoir. This time should be about 23 seconds (not mandatory).

11. Carefully lift the burner from its base and clamp it to the swivel plate inclined to 45 degrees.

12. Suspend one sample of 51mm x 350mm strip in a vertical direction. The upper end is held in a clamp and the lower end is pushed in the slot provided inside the test chamber (Ref to Fig. 3).

13. Adjust position of the burner by moving an external lever so that flame can contact the lower tip of the suspended test sample.

14. Switch on the exhaust fan for the exhaust hood and also start the fuel supply from the reservoir.

15. Close the front door of the cabinet and supply the flame to the test material for 20 seconds using a stop watch.

16. Observe the continuous burning time of the sample and also record the glow time, if any, after removal of the ignition source. Should the material shrivel away from the flame, reduce the flame application to 10 seconds for the subsequent trials. If the material shrivels again, suspend the test and mark "inconclusive" on the observation record sheet.

17. Open the front door and clear all the smoke before reloading the second sample.

18. If there is no shrivelling of the material observed in the first trial, repeat the test for the remaining five samples and record all the observations.

19. Cut off the fuel supply to the burner and switch off the exhaust fan when the smoke is cleared.

20. Mark the tested samples with a sequence number and take a picture with a polaroid camera after arranging them in a row.

21. Note any additional observations on the data record sheet.

22. Clean the apparatus and replace all the items where they generally belong.

23. Discard the tested samples in a garbage drum.

24. Note any malfunction of the apparatus in the log book provided with the apparatus.

Evaluation Criteria

Material shall fail the test if any of the following occurs.

1. (a) flame from any part of the test pieces extends above the marker wire.

1. (b) the glow of the material extends above the marker wire.

2. If after the burner flame has been removed,

   (a) the mean persistence time of the flame of the six test pieces exceeds three seconds, or if the persistence time flame on any one test piece exceeds 10 seconds.

   (b) the mean persistence time of the glow of the six test pieces exceeds 10 seconds or if the persistence time of the glow on any one test piece exceeds 30 seconds.

NOTE: Glow time shall be measured from the instant of the removal of the burner flame from the test piece. The requirments of 2a and 2b above refer to the suspended test piece and to any portion that may have fallen from the test piece.

Safety Precautions

1. Be very careful while loading the samples inside the test chamber when the burner is still on. Make sure that the burner is out of the way. Accidents have occured in the past causing some burns on the operator's arm.

2. Never rush to do the test; always take your time.

3. Double check the fuel line and its connection to the burner to ensure that there is no leak.

4. It is preferable to have two operators working together for safety reasons and to act as a witness of the tests performed.

5. WARNING: The large scale gallery test was introduced at CEAL based on a very similar test (medium size) used by the Mining Safety and Health Administration in the U.S. In our laboratory, there is lack of ventilation control as the flow in the gallery appears to be

non-laminar. Although the nominal velocity is 1.5 m/sec, we have recorded velocities as high as 2.3 m/sec. Consequently, when the flexible material is freely suspended in the ventilated gallery, it tends to flutter violently making it difficult for the operator to apply the flame manually particularly if the material is shrinkable under the flame.

A responsible engineer must be present to supervise testing and to advise the technicians where necessary.

ACKNOWLEDGEMENTS

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REFERENCES

1. NCB specification # 245/1961 and NCB specification # 568/1971.

2. Flammability training course material by N.K. Sarin.

3. Interim large scale test for flammability of brattice cloth by Dr. K. Mintz.

Table-1

VENTILATION MATERIALS
LARGE SCALE FLAMMABILITY TEST

Manufacturer:..... File:.....

Client:..... Sample #.....

Tested By:.....Checked By:..... Date:.....

Witnesses:.....

Product Identification:.....

Ventilation velocity:.....Ambient Temp:.....

Continuous burning times in seconds

Trial #	Gallery Test		Remarks
	still air	ventilated	

Other Observations:.....

.....

Verdict: Pass/Fail

Reported By:.....

Dated:.....

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Table-2

VENTILATION MATERIALS
SMALL SCALE FLAMMABILITY TEST
NCB Spec: 245/1961.

Manufacturer:..... File:.....

Client:..... Sample #.....

Tested By:..... Checked By:.....Test Date:.....

Witnesses:.....

Product Identification:.....

Continuous burning times in seconds

Trial#	20 Sec Flame Exposure		10 sec Flame Exposure.		Remarks
	Flame time.	Glow time	Flame time.	Glow time.	
Total .					
Average.					

Other Observations:.....

.....

Verdict: Pass/Fail.

Reported By:.....

Dated:.....

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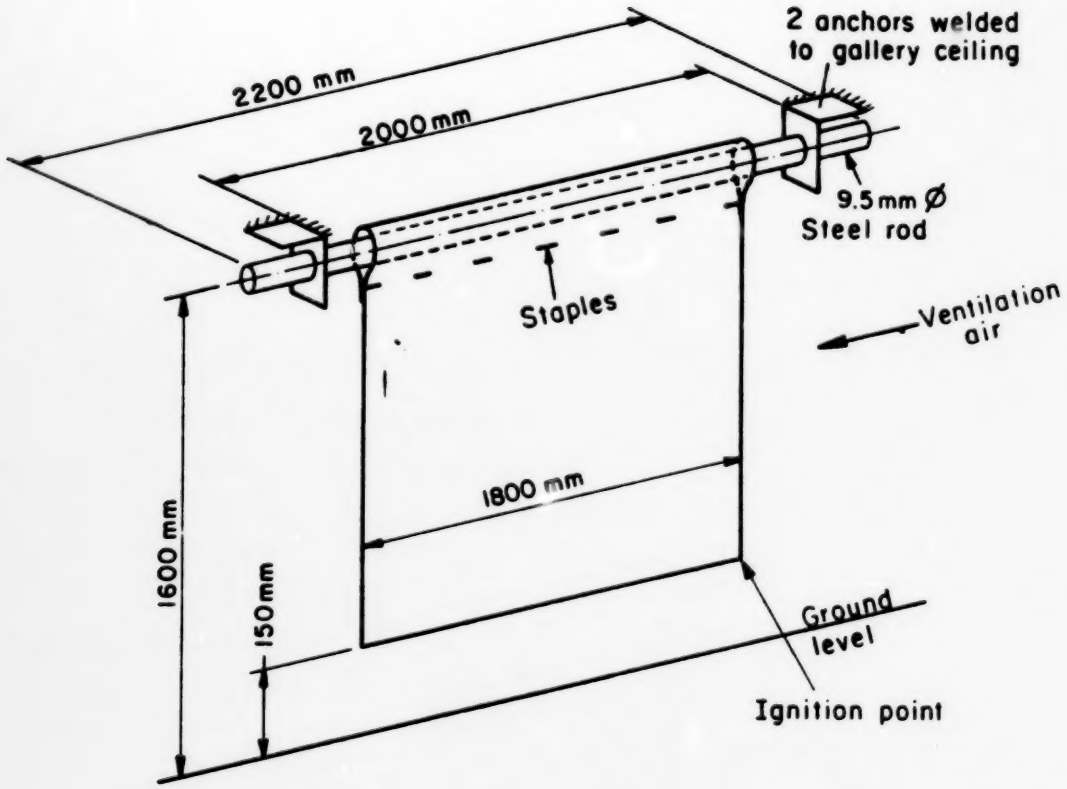

Fig. 1 - Layout of suspended brattice cloth.

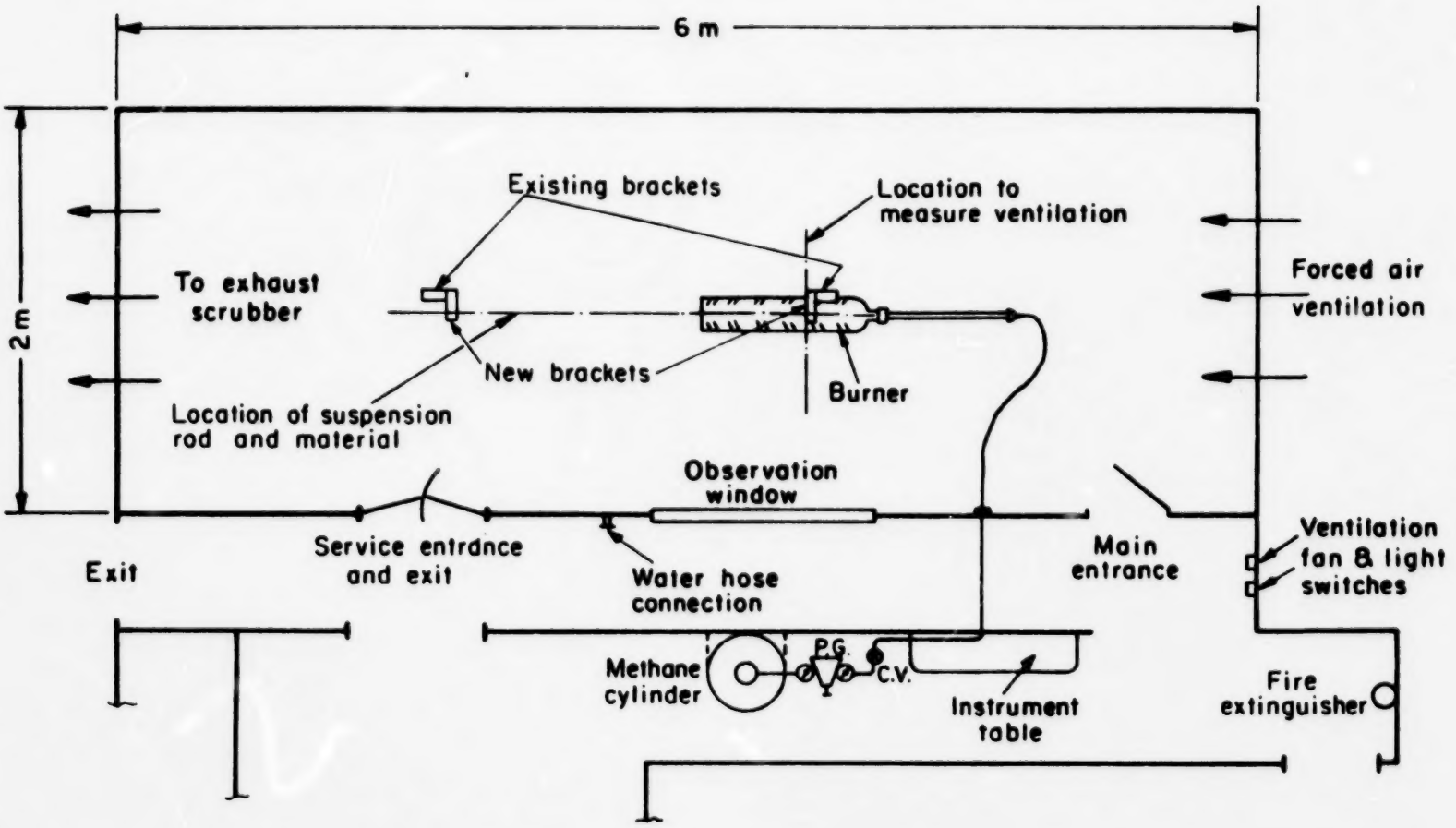

Fig. 2 - Layout of large scale gallery test for flexible plastic sheets.

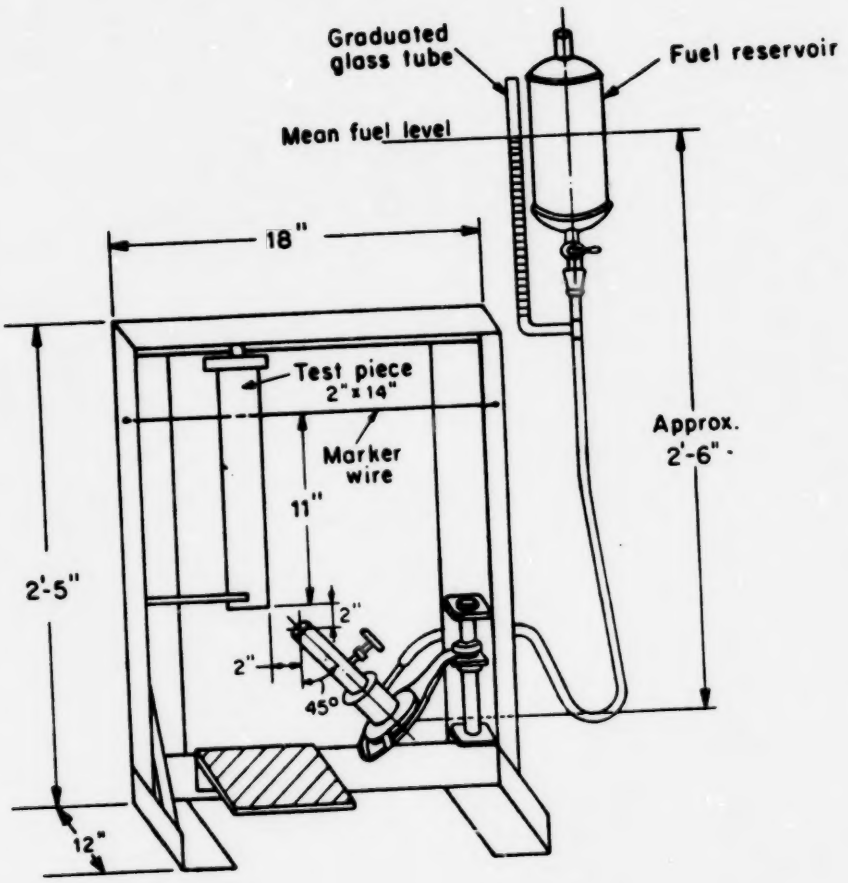

Fig. 3 - Apparatus for small scale test, NCB Specification 245/1961.

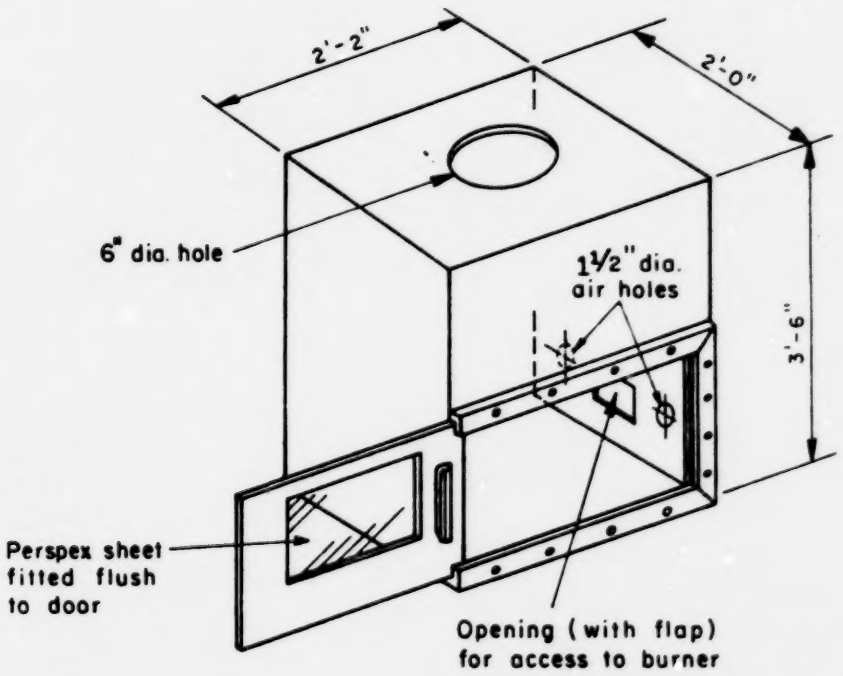

Fig. 4 - Draft free cabinet for NCB test.

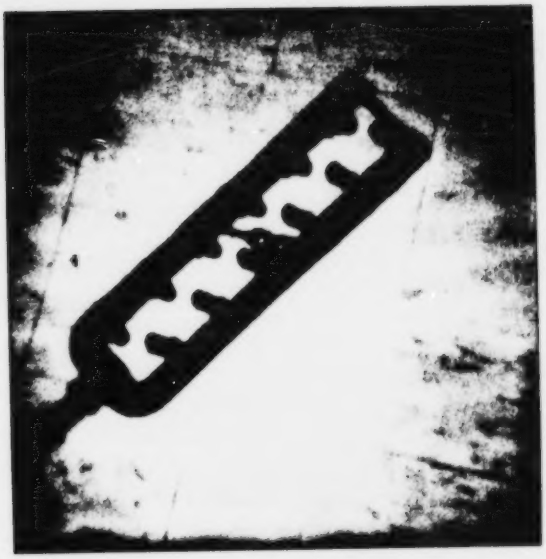

Fig. 5 - Jet burner for large scale test.